No. XIII.

MICROSCOPE FOR ANIMAL AND VEGETABLE DISSECTIONS.

The SILVER ISIS MEDAL *was presented to Mr. H.* SLACK, *43, Berners Street, Oxford Street, for his Microscope for Animal and Vegetable Dissections.*

SIR, 43, *Berners Street, Dec.* 1831.

I BEG to transmit to you the accompanying drawing and description of a Dissecting Microscope, and request you to lay them before the Society.

Being in want of a microscope chiefly for the study of vegetable anatomy, and not meeting with any cheap and simple instrument sufficiently steady for that purpose, I was induced to have one constructed on the following plan; and on trial have found it to answer remarkably well. It is convenient for ordinary observations, as well as for dissection; and by a few additions may be made, if required, to serve as an instrument for accurate microscopic research. In the last capacity it is, of course, not intended to vie with more complicated and expensive microscopes, but for dissection it surpasses them, in affording a firm stage, and substantial support for the hands of the operator. The usual mode of affixing the stage to the stem of the microscope renders it liable, by the pressure of the fingers, to spring from the magnifier; and in few cases do the stages give adequate support to the hands of the dissector. In the present instance these

faults are removed, by the stem being fixed to the back of a strong wooden case, which also supports the stage, and by two inclined surfaces gives an easy rest to the hands; therefore, any weight on the stage or case must tend materially to steady the whole. The stem, having to support only the lens, is rendered much more simple in its construction.

I am, &c. &c.

A. Aikin, Esq. HENRY SLACK.
Secretary, &c. &c.

Reference to the Figures.

Fig. 4, Plate V., is a perspective view of the case open. It is a foot in length, seven inches high, and four inches in breadth. The surfaces *r r* are sloped off to four inches square, and the top *g* is left six inches by four. The case is seen open in front, but provided with a flap hinged below and locking to the top, thus forming a complete box, in which all the apparatus connected with the microscope may be packed away. A drawer may be conveniently fitted to the upper part, to contain lenses, dissecting instruments, slips of glass, &c., still leaving sufficient room for all the brass-work below. The mirror seen in fig. 4 is of considerable size; it has two surfaces, one concave, the other flat; it moves in a socket let into the middle of the bottom, and directly over it, in the top, is an opening of an inch and a quarter in diameter, closed in fig. 4 by a brass cap *g*, which screws into a plate on the top of the case; this being removed, the stage *h* is screwed in, as seen in fig. 5, a back view of the microscope arranged for use. The stage is about three inches by two and a quarter, with an aperture of an inch; it is raised an inch

from the top of the case by a tube of that length, attached to it and sliding over another, which screws into the plate on the top of the box, thus allowing the object to be turned round to any convenient position. It is provided with a finger-spring for securing slides or slips of glass, and is in all respects but size similar to that represented in Plate VI., fig. 8, of the 48th volume of the Society's Transactions.

The plate *i i*, fig. 7, is seen in fig. 5, *i i*, let flush into the back of the case; it contains a groove into which the plate *j j*, fig. 7, slides, to which plate the socket holding the rack and pinion is attached. A top view of the plate *i i*, with the groove for receiving the plate *j j*, is seen in fig. 6. The vertical stem *k*, figs. 5 and 7, which supports the lens-arm, is six inches long and four-tenths of an inch square, fitting into a socket attached to the plate *j j*, figs. 6 and 7, and raised or lowered by an accurately-made rack and pinion, the latter having a milled head *l*, figs. 5 and 6, two inches in diameter; in its circumference are drilled eight holes, fig. 6, *l*, to receive a lever *o*, fig. 5, a steel bar about four inches in length. By the large milled head the observer is enabled to make very accurate focal adjustments; and the nicety of movement is still further increased by being made at the extremity of the lever. In this manner lenses of the highest powers may be very accurately adjusted. The lenses are supported by the sliding bar *m n*, fig. 5, moved by a rack and pinion at *m*, and the whole turning with a steel pin in the top of the stem *k*; the hole for this pin is seen in fig. 6. In this manner the lenses may be made to traverse any part of the stage. The ring *n* is made of just sufficient depth to hold the lens-cells, and its sides are filed off to admit of the free use of dissecting instruments.

The diameter of the lens-ring is six-tenths of an inch; and as several microscopes lately constructed have rings of this size, it may be mentioned as one allowing of the comparison of lenses and their employment in various instruments. It should also be stated, that the lenses drop in without a screw, being by far the more preferable method. Fig. 8, *n* is a section of the lens-ring, shewing the edges bevelled off below; the rise in the middle *m* shews the thickness of that part of the arm on which is the rack-work, the ring itself being only sufficiently thick to hold the cells of the lenses. The plate *i i* is purposely placed about an inch to the right of the middle of the back, in order that the lens-arm, with its rack and pinion, may clear the cheek of the dissector.

In fig. 5, *p p* are two brass pins, four inches in length; between them is stretched the curtain *q*, made of black cloth; the pins are fixed in holes in the front of the top of the box. This curtain is used in the examination of transparent objects, as it is then necessary to intercept all light not coming from below; it is also useful in keeping the light of a lamp from the eyes of the observer. The pins are bent a little forwards, that the curtain may not be in the way of the head.

Such are the arrangements necessary for the dissection of transparent bodies; but if the object under examination be opaque, it will be necessary to employ a lens to condense light for direct illumination, or to use magnifiers furnished with reflectors. The former is perhaps the better method, and a condensing lens may be easily adapted, supported on an arm having suitable movements and fitting into a socket on the top of the case; when this is used the flap of the case should be closed, as no light must be admitted from below. Forceps for holding

objects may be applied to the instrument in the same manner as the condensing lens.

If it is required to fit up the microscope in a more complete manner, a stage, with a Wollaston light, and Mr. Turrell's, or other methods of moving the object, may be screwed into the aperture, in place of the simple stage for dissection. This nicety of movement is not required in dissecting, as very high powers cannot be used; neither is it requisite to define the light so accurately as when deeper lenses are employed. It will also be found that in ordinary observations, by a little practice, a very steady movement may be given to the object on the stage by the hands, if they have a sufficient support. A compound body may, if required, be adapted with an arm, and a steel pin to fit into the top of the stem *k*, the simple lens-arm being then removed; this may be effected, as seen in Plate VI., fig. 16, of the Society's 48th volume.

Fig 9 represents a pair of forceps, of a convenient form, to be used in dissecting. Cutting instruments are readily made, by fixing needles into short wooden handles, and grinding them to suitable edges on a hone.

Description of Plates VI. and VII. illustrating the Elementary Tissue of Plants, with some instances of Vegetable Circulation.

The accompanying representations of the objects to the dissection and examination of which my microscope has chiefly been applied, were engraved at the instigation and through the liberality of Mr. Solly, for insertion in the Society's Transactions, as a supplement to the description of the Dissecting Microscope. They must be regarded principally as specimens of microscopic workman-

ship, having little claim to original discovery. The observations on the motion of fluids in plants may not be uninteresting to many of our members who have read the excellent description of the circulation in the *chara vulgaris,* given by Mr. Varley in the last volume of the Transactions. The figures in Plate VII. must be considered rather as plans to render description more intelligible, than as very accurate delineations of the beautiful phenomena witnessed on actual inspection, of which it would be impossible by drawing to give a very precise idea. The superior manner in which the engravings have been executed by Mr. Turrell, has given to the vegetable tissues the exact appearance which they present under the microscope; and I think are not equalled by any hitherto engraved.

In Plate VI. are represented some of the principal varieties in the primary forms of vegetable tissue. As these are not drawn to a precise scale, it will be necessary hereafter to give some explanation of their average size.

The elementary organs of plants are usually classed under four distinct heads: cellular tissue, woody fibre, spiral vessels, and ducts; but we find these tissues all nearly allied in structure, and in many instances passing by insensible gradations from one form to another. They may all be considered as composed of a delicate, transparent, apparently imperforated membrane, forming a closed sack, either nearly spherical, dodecahedral, fusiform, or very irregular, as in the vesicles of cellular tissue; or elongated into tubes, with conical terminations, as in woody fibre, ducts, and the membrane surrounding the thread of spiral vessels. This sack in the cellular tissue and woody fibre is usually found perfectly simple; but in spiral vessels, and in most ducts, a peculiar fibre or

thread is developed within, assuming a variety of forms. Reticulated and dotted vessels, and vesicles of cellular tissue, may be shewn in many cases to arise from adhesions in the original spirally-developed thread. There are, however, cases of dotted cellular tissue, woody fibre, and perhaps some ducts, in which the markings are not at all referable to this cause, but appear to be bodies adhering to the membrane, and not dots or perforations in its substance.

In Plate VI. fig. 1, is represented what may be considered the normal form of cellular tissue, consisting of nearly spherical vesicles, of a membrane perfectly transparent, and presenting no markings or visible perforations. The variety of form assumed by the cells in different plants, and in different parts of the same plant, appears generally to arise from the variations of pressure to which they are subjected. In fig. 2 are seen cells losing their rounded form by compression. Fig. 3 exhibits cells composed of a membrane, as the last, with the addition of spirally-developed threads within; the latter always adhere to the membrane, hence it is lacerated when they are unrolled. This may have given rise to the idea that the fibres were connected by a membrane, and not inclosed in a membranous sack; but the smooth surface of the cell indicates the correctness of the latter opinion. In fig. 3, *a*, the fibre is partly unrolled, and the cell torn open. The cells in fig. 4 are apparently formed of a thread rolled closely on itself, and the existence of an enveloping membrane is not evident. Intermixed with these we find simple membranous cells, as at *a*. In the same plant from which fig. 3 is taken, may be seen cells, as in fig. 5, presenting small areolar spaces, and traces of the original spiral fibre between them. The dots are

parts of the membrane uncovered by the internal spiral thread, which in other places is adhering to itself. These vesicles appear a transition from fig. 3 to fig. 6, in which are represented cells from the same plant, the dots only remaining, and the original spiral threads having entirely grown together. These spiral and dotted cells are found chiefly in orchideous plants. Figs. 3, 5, and 6, are taken from a preparation of Mr. Valentine's. Simple membranous cellular tissue may be seen in every plant. The size of the cellules of this tissue is very variable: they are usually from $\frac{1}{300}$th to $\frac{1}{500}$th of an inch in diameter; but may be found of all sizes, from $\frac{1}{30}$th to $\frac{1}{1000}$th of an inch. In fig. 7 are seen vesicles rather elongated, and without spiral fibres or markings. Fig. 8 represents a small spiral vessel, which may be considered a membranous envelope like the cell *a*, fig. 7, within which a spiral thread has been developed. Figs. 9 and 10 are elongated cells from the wing of the seed of *bignonia multifuga*, drawn from a preparation put up by Mr. Griffith. In fig. 9 are seen traces of a spiral fibre, which has partially grown together, giving rather a reticulated character. In fig. 10 the cells are dotted, and we see no remains of the spiral thread. It appears, then, that the same relation exists between figs. 7, 8, 9, and 10, as between figs. 1, 3, 5, and 6; and that a similar transition is indicated. Figs. 11, 12, and 13, are also similarly related; fig. 11 represents simple cells, placed end to end; fig. 12, cells with a spiral fibre, somewhat elongated, and in the same position; fig. 13 is apparently a continuous tube, or a dotted duct; its origin, however, is indicated by joints at regular intervals. In the first place, spiral cells, placed end to end, as in fig. 12, may have become dotted by a transition, as shewn in figs. 3, 5, and 6,

and then the membrane sometimes becoming obliterated entirely or partially at the points of junction of the vesicles, this kind of jointed dotted duct will result. In ducts of this description the membranous septum often remains. The vessel represented in fig. 13 is taken from the *hippuris*. It may be observed, that the elongated cells of figs. 7, 9, and 10, appear to be an intermediate stage between cellular and woody tissue.

The existence of a closed membranous sack in all cases of cellular structure may at first sight be considered as disproved by the cells shewn in fig. 14, which are placed end to end, and apparently have open extremities, as at *a* and *b*; it may be that at *c* and *d* the membranous partition still exists, and by removing the cells that adhered at *a* and *b*, the membrane was torn away. However, the formation of continuous tubes, by the obliteration of parts of cells in juxtaposition, is of frequent occurrence. An example of this is seen in fig. 15, which represents two joints of a long dotted duct taken from the *dahlia*, and no doubt similar in its origin to fig. 13. When the conical terminations of two ducts are in close apposition, the membrane at the point of union will often be obliterated, and transverse bars only remain, as seen in fig. 14½, which is the termination of a duct from the *phœnix dactylifera.* This dotted duct, supposed, as will be mentioned hereafter, to owe its origin to the adhesions of an internal spiral fibre, was applied to a neighbouring vessel by the surface *a b*, which has the appearance of a grating, arising from the remains of the original spiral fibre stretched across the opening where the enveloping membrane has disappeared. It will be seen that these transverse bars, being remains of the original spiral fibre, pass away from the membrane always between the dots on the duct: this

is one indication of these dots being merely parts of the membrane, uncovered by the internal fibre. The appearances in figs. 5, 6, 10, 13, 14½, and 15, are not supposed to arise from mere adhesions; but must, of course, be attended with some transverse growth of the internal fibre, as well as from its becoming branched

Proceeding now to the spiral and annular vessels, and reticulated and dotted ducts, we shall find that we are not entering on entirely new structures, but that these bear great similarity to the forms of cellular tissue above described. This similarity of conformation must deter us, in some measure, from ascribing to the cellular and so called vascular tissue entirely distinct functions in the economy of plants.

A spiral vessel appears to consist of a very elongated, membranous tubular cell, with conical closed terminations, and one or more fibres developed spirally within. The existence of an enveloping membrane is not always evident where the coils of the spiral thread are in close contact, and when the fibre is unrolled it is not rendered visible from its intimate adhesion to the thread, being lacerated as the latter unrolls. In fig. 16 is a portion of a simple, membranous, conically-terminated tube, which occurs in many plants, and is larger than the ordinary woody tissue. It is well seen in the asparagus. If we suppose a single fibre closely rolled on itself to be developed within, we should have a vessel as represented in fig. 17; if two or many fibres are developed, we have compound spiral vessels, as seen in figs. 18 and 19. The fibres of a compound vessel are found always to run in one direction, forming usually a right-handed screw; see fig. 18. This may be clearly seen if only the upper surface of a vessel be kept in focus. The error of sup-

posing the spires to run opposite courses in the same vessel, arises from having the upper and under sides partially in focus at the same time.

The annular vessel may be either composed of distinct rings enclosed in a very apparent membrane, as fig. 21, *a*, or it may consist of perfect rings, and rings attached to portions of spiral fibre, as in figs. 20 and 21, *b*. These rings in some vessels are very close, in others at considerable intervals. If we follow these vessels to any extent, traces of a spiral fibre may generally, if not always, be found. It is probable, as we find vessels in all states of transition, from perfectly spiral to ringed, that the original tendency was to develope a spiral fibre; but that, during the vessel's formation, the enveloping membrane grew faster than the fibre, and the latter was consequently broken and contracted into rings. This would, perhaps, account for the formation of such vessels as figs. 20 and 21, *a b*; but we meet with annular vessels in which the rings are almost in contact, and therefore we can hardly explain their construction in this manner. Fig. 20 represents part of a vessel taken from the leaf-stalk of the culinary rhubarb; it seems originally to have contained a single spiral fibre, which by bifurcating gave the appearance of a double spire, as at *a*; these two fibres then reunite. Examples of a similar bifurcation and tendency to branching in the fibre are seen in *c*, fig. 21. In fig. 20 the single thread was broken at *c*, and coiling on itself formed a ring; the next two were formed in the same manner, but remained united by a part of the spiral fibre. At *d* a ring has arisen from the adhesion of the fibre, and beyond are two perfect rings. The distance of the rings may, in part, depend on the closeness of the original spiral fibre, but may also be influenced by the

subsequent growth of the part of the plant in which the vessel is situated. The three vessels in fig. 21 are taken from the same bundle in the petiole of the rhubarb; and it will be seen that *a* is of less diameter than *b*, *b* than *c*, and that the rings in *a* are farther apart than in *b*. Now, it is probable that the vessel *a* was formed when the leaf was little developed, *b* when it was more grown, and *c* still later; the size of the vessels bearing in each case, at the time of their formation, the same proportion to the petiole. The vessel *a* having existed during a longer period of the plant's growth than *b*, may account for its having a greater number of perfect rings, and for the rings being at longer intervals. Had the petiole continued growing, the vessel *c* might have assumed the character of *b*, and *b* of *a*; or even *c* might at last have been reduced to the same appearance as *a*. These transitions are actually commencing in other parts of the vessels shewn in fig. 21. The figure represents only small portions of the three vessels.

Figs. 22, 23, 24, and 25, illustrate the transition from spiral vessels to reticulated and dotted ducts. In fig. 22 are parts of two vessels taken from the rhubarb. The vessel *a* is seen at *c* to have a double spire, which, no doubt, arose from bifurcation of a single fibre, as in *c*, fig. 21; at *d* and *e*, by the growing together of the fibres, it is becoming reticulated, and at *f* it assumes a dotted appearance like that seen in the vessel *b*, in which the transition to a dotted duct is completed, that is, completed in the part of the vessel there shewn; but in tracing it through its whole extent we should see parts having a reticulated character, and even traces of the original spiral fibre. In the formation of the ducts in fig. 22, the internal fibres appear not only to grow together, but in

some parts to send out connecting processes, as seen at *d* and *e* in the vessel *a*. As we consider the more perfect ringed vessels, and those in which the rings are at the greatest intervals, to have existed during the period of the plant's principal elongation, so we may conceive that ducts, as *b*, fig. 22, arising from adhesions and growth in the spiral fibre, are formed when the plant has nearly ceased growing. We may adduce the fact of *b*, fig. 22, having a greater diameter than *a* as a proof of its later formation. Fig. 23 is a reticulated vessel taken from the hyacinth root. It is formed in a similar manner to the last, but here the adhesion of the fibre has not gone on to the formation of a dotted duct. Fig. 24 is a portion at the termination of a vessel in which the fibres were originally closer than in the preceding, and therefore when partially grown together the dots are smaller and more numerous. At *a* it is a little unrolled, shewing its spiral nature, which, however, might be clearly seen without unrolling if the vessel were traced to any extent. At *b* is seen the usual conical termination of these ducts. Fig. 25 is a part of a duct on which the dots are more uniform in size and regular in arrangement than in the preceding. Its origin from the adhesions of a spiral fibre is less evident, as it is dotted throughout; yet, from its unrolling spirally, as seen at *a*, and its close analogy to vessels like *b*, fig. 22, this may perhaps be considered as the mode of its formation. Similarly dotted ducts often present transverse markings, indicating a division into cells, as before shewn in figs. 13 and 15, where their probable origin was also explained. Dr. Bischoff considers the dots on such ducts as fig. 25 to arise from the spiral fibre being broken into small pieces, which adhere to the membrane; and he conceives the transition to be from spiral to ringed vessels, and from the

latter to dotted ducts. An imaginary figure of Bischoff's is given by Mr. Lindley in his lately published "Introduction to Botany," a book which may be recommended to all students as the only English work by which they may obtain a correct knowledge of the science of botany as it now exists. If, however, the dots on this kind of duct are to be accounted for by any change in an internal fibre, their origin from its growth and adhesion is perhaps the more probable opinion. It is supported by their analogy to other vessels, as those represented in fig. 22, *b*, and in fig. 24; and the fact of the ducts unrolling spirally cannot be accounted for by the circumstance of small fragments of the fibre adhering to the membrane; but it might be supposed that such would be the case, if the continuity of the internal fibre were not destroyed.

It may here be stated, that in figs. 16, 18, 19, and 22, *a* and *b* are in the same relation to each other as the cellular tissue represented in figs. 1, 3, 4, 5, and 6, or as the more elongated forms in figs. 7, 8, 9, and 10; from all of which they differ only in being more elongated. The size of spiral vessels is very variable; but their diameters will in most cases be found to be between $\frac{1}{400}$th and $\frac{1}{1000}$th of an inch. Ducts, especially the dotted ducts, are usually larger than spiral vessels. Annular vessels are often about the $\frac{1}{400}$th or $\frac{1}{500}$th of an inch in diameter, but may occur considerably smaller.

Woody fibre, as shewn in figs. 26, 27, and 28, consists of a simple transparent very elongated cell, either terminated conically at both ends, as in fig. 26, or obliquely truncated and rounded as in fig. 27; it may also have an abrupt termination. In the fibrous structure of plants we often meet with tubes open at their extremities, as in *a*, fig. 27: this probably arises either from the membrane

being obliterated where it was applied to another fibre, or ruptured by the pressure of an adjoining cell, as we sometimes find the conical extremity of another tube inserted into the aperture. The tubes are of all diameters, from the $\frac{1}{200}$th to the $\frac{1}{3000}$th of an inch, and also very various in length. We often find elongated cellular tissue in the situation of woody fibre in plants not strictly woody, and cells of all possible stages between spherical vesicles and ordinary woody fibre. The membrane of woody fibre is more firm and elastic than that of the usual forms of cellular tissue; but as the latter assumes a more elongated character, the membrane appears to approach that of woody tissue. The more attenuated forms of cellular structure are perhaps furnished with a stronger membrane to prevent the continuity of their cavity being destroyed by lateral pressure. This may also be the function of the internal fibre in the varieties of the vascular system, and, perhaps, in the spiral cellular tissue, where the vesicles appear larger and the membrane thinner than in the more common forms. The enveloping membrane of spiral vessels and ducts is very delicate, and therefore requires this internal support. The solidity of ducts appears to arise from the adhesions of the internal fibre, and not from a greater firmness in the membrane. In woody fibre markings are rare; but they do occur, as seen in fig. 29, which is fibrous structure from a Nipal wood. The irregular dots there seen are not at all traceable to the adhesions of an internal fibre, but appear to be small bodies adhering to the membrane. This is also the case in some kinds of cellular tissue, an example of which is seen in fig. 31. Fig. 30 represents portions of tubes which are found in the wood of coniferous plants: the drawing was taken from a dissection made by Mr. Valentine. Adhering to

the surface of the membrane of these tubes are small circular bodies, with a more prominent and rather more opaque and smaller circle in the centre. These bodies are convex, and project slightly from the tube, down the sides of which they are arranged in two opposite rows, and are only to be seen by making sections in the direction of the medullary rays. Woody fibre may sometimes have a branched appearance, as in fig. 32; but this evidently arises from the partial adhesion or growing together of two distinct fibres. Spiral vessels have also been said to branch; but this appearance certainly arises from the adhesion of two or more vessels: cases like that represented in fig. 33 are of frequent occurrence. It is there evident, that at *a* and *b* we have terminations of two distinct vessels, and that *c* is a small spiral vessel connecting *d* and *e*, to which it has intimately adhered.

There are vessels, described by M. Schultz under the name of vital vessels, which appear to have a structure quite at variance with any of the forms above described. He states them to be continuous tubes, anastomosing with each other, and conducting a fluid which passes readily through all their ramifications. These will be mentioned again in the description of Plate VII., where portions of them are delineated in figs. 19 and 20. There is, however, another, and perhaps a universal motion of the vegetable fluids, carried on in the cellular structure of plants; each cell having a motion of its contained fluid apparently independent of its neighbours. The figures in Plate VII. are examples of the latter kind of circulation, or rather rotation, of the fluids of plants.

In fig. 1 is seen a portion of the *nitella flexilis*, of its natural size, a plant nearly allied to the *chara* described by Mr. Varley in the last volume of the Transactions,

being placed in the same natural order. It differs in being composed of single transparent tubes, with but little incrustation; the stem and branches are jointed precisely in the same manner as the *chara vulgaris;* but it has not, like the latter, an outer coating of smaller tubes. The branches, or, as they are sometimes called, leaves, are six in a whorl, as seen at *a, b,* and *c*; these often develope from their axillæ young shoots as *x* and *y*. The branches are seen to bifurcate at their extremities; the fork consists of two distinct tubes, and the rest of the branch of a third. The part of the main stem between the whorls of branches is always one continuous tube, the joints occurring at the whorls. The plant is of a bright green colour. Fig. 2. is a magnified portion from the extremity of the plant, fig. 1, *d,* shewing the motion of fluid in all its joints. Four branches only in the lower whorl are shewn in the figure, to render it less complex. They are not yet sufficiently developed to exhibit the bifurcation represented in fig. 1, *a* and *b*; but small shoots, as *x, y,* and *z,* are beginning to appear. In all the joints will be seen an ascending and descending current, as in the *chara,* separated by the quiescent colourless lines *a a,* two of which are seen, one on either side of all the tubes. These lines wind spirally round the plant; and, taken in the successive joints of the stem, they appear to form two continuous lines throughout. The same may be observed in the branches: referring to fig. 2, the line *a a* will be seen, by the direction of the arrows in the lower part of the stem, to separate the ascending current *g* from the descending *f*. The line *a a* in the upper joint of the stem continues exactly in the same direction which it held in the lower, and still divides the ascending and descending currents; of the former, but a small portion can be seen, owing to

the quiescent line winding spirally behind the joint. Although this regularity in the direction of the currents of succeeding joints is invariable, yet not the slightest communication is observed between them, as the ascending is continuous with the descending both above and below in each articulation of the plant; thus a rotation of the current is kept up in each cell, and the same particle floating in the fluid may be traced throughout its whole course. The two transverse currents observable at every joint must of course be in opposite directions. In the branches it is remarkable, that at their origin from the stem the ascending current is always farthest from the axis, the descending nearest to it; the quiescent lines commence between the two, and continue their spiral course throughout the extent of the branch. Where a bifurcation exists, as seen in fig. 1, one of the tubes appears a continuation of the original branch, fig. 2, *l m n o*, while the other is developed laterally, and is usually smaller; in this the ascending current commences farthest from the axis of the branch, the descending is nearest to it. This appears to be the case with all lateral developments, whether from the stem or branches. It is indicated in the branches composing the head *s*, by the direction of the arrows. Surrounding the base of every branch we see small cells, apparently within the main stem; in these I have not seen the motion of the fluid, although in all probability it occurs. Each joint of the plant is composed of one external glassy tube, closed at the extremities. Within this, and contracting a very slight adhesion to it, is a layer of minute green cellules in close apposition, but easily separated by pressure. These alone give the colour to the plant; they cover the internal surface of the tube in all parts but the transparent quiescent line, which,

indeed, is only formed by their absence. The moving fluid, with all the particles it contains, is evidently internal to this cellular structure; it appears to revolve round an axis composed of a delicate membranous sac, which contracts an adhesion to the outer glassy tube in the whole extent of the quiescent line. This internal sac is no doubt filled with fluid, perhaps differing from that we observe in motion; it certainly contains no globules or particles of any description when the sac is entire. The existence of this internal membrane is demonstrated in fig. 3, which is a view of two joints of a branch more highly magnified. This view is taken by bringing a plane, passing through the centre of the tubes, into distinct focus. The dotted lines *a a* represent the situation of the quiescent line in both joints. A wavy line is now seen, indicating clearly the outline of the internal membranous axis, between which and the external glassy tube, with its cellular lining, the currents exist. The membrane is seen most distinctly where it is thrown into waves by the passage of masses of the floating particles, as at x and y. The arrows without the joints shew the direction of that part of the current most distinctly in focus, seen between the wavy line and the external tube. The arrows within point in the same directions, for they indicate the course of parts of the same currents, which are not so distinctly in focus, and in the present situation of the branch are passing upon the internal membrane around the quiescent line *a a*. This may perhaps be better explained by reference to the diagram in fig. 3½, which is a horizontal section of the stem. Here the outer tube with its lining of cellular structure is seen; the latter wanting at *a a* the quiescent lines, where the internal membrane *e f* adheres to the outer tube; *d* is the axis enclosed by the membranous sac. The dotted

line *b c* indicates the plane which we have distinctly in focus. The rotating fluid with its particles is seen between the membrane *e f* and the outer tube. Suppose the side *c* the ascending, and *b* the descending current, we should see the currents and internal membrane distinctly where the line *b c* passes through, and have also a less distinct view of those parts of the currents above the line; they would appear ascending and descending, as shewn by the arrows within the joints in fig. 3; but the quiescent line *a* could not be clearly defined, as it must be considerably out of focus to obtain a good view of the plane shewn by the dotted line *b c*, fig. 3½. That the moving fluid is within the green cellular structure, may often be well seen at the extremity of a branch, where the outer glassy tube, as at *c*, fig. 3, has developed beyond the green lining, a portion of which is seen at *b*; but this is also proved by the fact, that on approaching the lens to a specimen of the *nitella*, the green cellular structure always comes into focus before the particles which float in the rotating fluid. Secondary rotations of masses of globules are sometimes observed directly beneath the quiescent line, evidently receiving their impulse from the two currents. This may arise from the rupture of the internal sac, and the entrance of particles from the external currents into its cavity; these collect in a mass in the dense fluid of the axis, and are made to rotate by the passing ascending and descending streams. This is shewn in the diagram, fig. 4, where the dotted line *a a* is the situation of the quiescent line; the principal streams are marked by the large arrows, and the motion of the mass of particles is indicated by the three smaller ones. It is a curious fact, that the particles seen floating in the currents have the colour and usually the form of the cellules composing the green

lining of the tube in which they are rotating. The moving particles are, however, sometimes very irregular in form; they then appear to consist of small equal cellules, but adhering in different numbers; the same small cellules are then observed to unite and form the larger bodies of which the lining of the glassy tube is composed. Examples of this are seen in figs. 5, 6, 7, and 8. In fig. 5, *a*, are seen globules taken from the circulating fluid in a specimen of the *nitella;* in *b* is represented a portion of the green lining, seen in this case to be composed of bodies exactly analogous to the particles in the currents. This form appears generally to exist in newly developed parts of the plant. In fig. 6, *a*, are globules of rather a different appearance from the last; they present lines indicating a formation by the aggregation of smaller particles; bodies analogous to the latter are seen floating in the rotating fluid, as well as the larger particles shewn in the figure. At *b* is a fragment of the lining from the same tube, shewing its composition of parts similar to the floating particles, but receiving some slight alteration in form, evidently by compression. In fig. 8 is another specimen at *a* of the floating particles; they here consist of smaller bodies adhering irregularly: these smaller particles, by their aggregation, appear also to form the larger bodies of the green lining in the same joint of the plant as seen at *b*. In fig. 7 are shewn spherical balls often seen floating in the circulating fluid; they appear of quite a distinct nature from the particles above described, being colourless, transparent, and perhaps composed of a dense fluid insoluble in that of the currents. They may, perhaps, be globules of fluid escaped from the internal membranous sac before mentioned; they are sometimes rendered rather irregular by small bodies adhering to their surface. There are

occasionally small and very irregular particles in the circulating fluid, which appear to arise from accidental circumstances, as they rarely occur in healthy plants. In fig. 9, *a* is a joint of the *nitella*, having an appearance of light and dark rings on its outer tube. The light rings are produced by incrustations of crystals of calcareous matter, similar to the coating of the *chara vulgaris*, but here occurring only at pretty regular intervals, the intervening dark portions being the usual green colour of the plant. At *b*, in fig. 9, is a magnified portion of the outer glassy tube, the fluid and green lining being removed; the latter, from its slight adhesion to the tube and its excessive brittleness, is easily separated by a little pressure. Here, at *x* and *y*, the incrustations of crystals are seen upon its outer surface, being an excretion from the plant. Small masses of crystals are seen dispersed over the plant's surface, even when growing pretty vigorously; but these circular incrustations are usually seen in sickly and dying parts. It may be stated that the above observations on the circulation in the *nitella* apply equally to that of the *chara vulgaris*, and, no doubt, to all the natural order *characeæ*.

In fig. 10 is represented a small portion of the *hydrocharis morsus ranæ*, or *frog-bit*, of its natural size. It is an aquatic plant common in ditches and streams. Surrounding its leaf-buds *b*, are very transparent scales, as at *c*, which may be examined under the microscope without farther preparation than placing them on a slip of glass in a little water, and covering the whole with a thin piece of talc. We then have the appearance represented in fig. 11, in which are seen a few flattened cells of the cuticle or outer layer, with the spiral vessel *a b* beneath them. In each cell we observe a motion of the fluid, marked by very regular oblong green globules, which creep

round and round the parietes of the vesicles, the arrows marking the direction of this rotatory movement in each, which will be seen to follow no particular law. The globules are not very numerous in each cell; they sometimes follow their course singly, at others they collect in masses, and still continue their movement around the cell. When two or three adhere, we often observe a wavy line between them and the axis of the cell, as at *d*; apparently an indication of some internal membrane, as described in the *nitella*. Nearly all the globules are found, in some cases, to collect in a mass, as at *c*, figs. 11 and 12, and then their movement ceases. In the flattened cells of the figure they usually fall on the border of the cell, but are sometimes seen to cross it. The motion of these green globules is noticed by Meyen, in a memoir on the movement of the sap in the cellular tissue of plants, published in the Transactions of the Academy at Bonn, in the 13th vol., 1826. He also describes a motion of particles in the hairs of the root. In fig. 11, a portion of one layer only of cellular tissue is shewn; as the cells are much flattened, and not always exactly in one plane in each layer; a second is usually partially in focus at the same time: this I have not represented in the figure, to render it less complex; it will be seen in fig. 12. Fig. 12 is a section of the stem of the *hydrocharis* (see *a*, fig. 10): the cells here are large and arranged in rows; between them, at *a* and *b*, are seen portions of a spiral vessel, torn away in the interval, and thus exposing a series of small very elongated cells, which in the entire plant surround the spiral vessel, and appear a stage between cellular and woody tissue, as they occupy the situation, and perhaps, in some measure, perform the functions of the latter in this plant. In the larger cells,

the rotation of the fluid is similar to that described in the cellular tissue of the scale. The globules appear here to follow the walls of the cell rather less closely, and in some instances cross the cavity, entering the current on the opposite side. At *x y z* is seen part of an under layer of cells, in which the globules move in the same manner. As the boundaries of these cells do not coincide with those of the upper layer, their currents will often appear to pass by an inter-cellular partition, giving rise, on first inspection, to the idea of a continuity between the cavities of the cells. It will, however, in these cases always be found, that the current belongs to one layer, while the partitions are those of another series of cells, both being in view at the same time. This will be readily understood by reference to the figure. In the small elongated cells around the spiral vessel, a rotation of the fluid is also observed; it is rendered perceptible by very small particles, which travel round and round, as in the larger cellular tissue; but as the particles are very minute, they may often be observed only on one side of a cell, which at first sight may lead the observer to conclude that there is only one current in each cell, and that these communicate, or are, in fact, continuous tubes. This error is corrected by witnessing the progress of the particles at the termination of one of the tubes, where they will be seen to turn round and descend on the opposite side to that on which they ascended: examples of this are given in the drawing. Another fact, which might lead to the same erroneous conclusion, is, that when a section is made the spiral vessel is seen frequently covering one side of the small cell, and consequently hiding one of the currents; this is seen at *d*, *e*, and *f*. The terminations of these elongated cells are seen with difficulty, and they

may easily be mistaken for continuous tubes. May not the vital vessels of Schultz be of the nature of the above-described cells, as he states them to be found surrounding the spiral vessels in monocotyledonous plants? By some a motion has been supposed to exist in the spiral vessels of the *hydrocharis*, but I think this must arise from the movement in the small subjacent cellules, seen through the membrane of the spiral vessel. Since making the drawings for figures 11 and 12, I have observed in all the cells of the *hydrocharis* a very transparent nucleus, shewn at *f*, in the cell *e*, fig. 11. This appears exactly similar to the nucleus of the *tradescantia;* and, as in that plant, we also see in all the cells of the *hydrocharis* a circulation of very minute particles, either following the course of the larger green globules, or as seen in the figure crossing the cell. These small currents, in most cases, have some relation to the nucleus, either appearing to pass over its surface or near it. The nucleus itself is sometimes seen to be carried along with the green globules, but it is usually stationary; it has a granular appearance, and perhaps consists of a number of the small particles in a state of adhesion. The smaller particles in the common cellular tissue are similar to those which are seen in the elongated cells surrounding the spiral vessels in the section of the stem. If there exist in the cells of the *hydrocharis* any internal sac separating the currents, as in the *nitella* or *chara* (and the presence of this axis is indicated by the wavy line before mentioned), then it is evident that both sets of particles must be external to it, and both float in the same fluid, as he observed the lesser following the larger globules, and sometimes one of the green globules traversing the cell in a current of the smaller particles, and apparently forcing its way along a channel which

will scarcely admit it. The nucleus being in connexion with the currents, must also be external. That there exists some axis round which the currents revolve, can hardly be doubted, for if not, why should the globules always follow the parietes of the cells, when the cavities of the latter would be filled with one continuous fluid? Their analogy to *tradescantia*, in which this appears to exist, might, with the wavy line above mentioned, be considered almost sufficient ground to warrant this conclusion; but in microscopic research every observer should record strictly those facts only of which he is perfectly convinced, for it is only by the coincidence of the results of many investigators that we can arrive at accurate conclusions. It is a curious fact, that by making the sections of the stem of the *frog-bit* we at first deaden the circulation; but on remaining a short time in water, it recovers its former velocity in the cells which have not been wounded. The small cells around the spiral vessel appear to retain their energy from the first, and seem little affected by the section: this may arise from their being less liable to injury on account of their size, or the membrane of which they are composed may be of a firmer character; this being usually the case in the more elongated forms of cellular tissue approaching to woody fibre.

In fig. 13 is a slightly magnified representation of a hair from the filament of the *tradescantia virginica.* Its beaded nature is there seen, each bead being composed of a distinct cell, in which we observe a large nucleus. In the drawing, about a third of the whole extent of the hair is shewn. When more highly magnified, we observe each cell presents minute longitudinal striæ on its surface. These I have not shewn in figs. 14 and 15, as their principal object was to explain the circulation. Fig. 14

is a magnified view of the terminal head. It will be seen that each cell consists of an outer, glassy, colourless, case, enclosing the colouring matter. The nucleus *a* is in this case situated at the base of the cell, and the currents of small particles, shewn by the dotted lines accompanied by arrows, appear to pass near it, or over its surface. These currents may often be traced through their whole course around the cell: this is shewn in the figure, where they are seen ascending in one part, descending in another, and sometimes two uniting into one. The same facts may be observed in fig. 15, which is one of the more elongated beads: here the nucleus *a* is also near the base of the cell, and the currents are seen ascending and descending in the direction of the arrows. The nucleus may hold various situations in the cells, as will be seen in fig. 13; it is of a rounded form and granular appearance, colourless and transparent, perhaps composed of particles similar to those existing in the currents. The structure of each cell appears to be an outer glassy tube, presenting the above-mentioned longitudinal striæ; between this and the colouring matter, the moving fluid, with its particles, exists. The coloured fluid of the hair seems to be enclosed in a membranous sac, which forms an axis around which the moving fluid revolves. The nucleus must also be external to the sac, as it is in connexion with the currents. Sufficient evidence of this membranous axis is given in fig. 16; a view of three beads which have been punctured and the fluid allowed to escape. The sac is here seen to have collapsed, and the nucleus *a* is evidently without it. That the colouring matter must be enclosed in a membrane is clear, even when the cells are unbroken, as a transparent, colourless margin is always seen between the colouring matter and

the external case. The circulation in the jointed hair of the filament of the *tradescantia* was first observed by Mr. Brown, and is described by him in a memoir on the *orchideæ* and *asclepiadeæ*, where he also notices the existence of the nuclei and the longitudinal striæ upon the surface of the beads. A nucleus exists in the cellules throughout the plant; and I have lately observed its accompanying circulation of small particles in all the cells. Thus, in fig. 17, which represents a beautiful, colourless, jointed hair, projecting from a portion of cuticle *d* taken from the calyx of the same plant, we perceive in each cellule a nucleus, with the currents usually having some connexion or communication with it. This hair is composed of three elongated cells, resting on a broader and shorter cell, which forms its base. The terminal joint *d* tapers to a point, and from its minuteness the circulation and nucleus are seen with difficulty within. I have in some cases observed both; but they are not delineated in the figure. In the succeeding cells *c* and *b* the nucleus is very distinct, and a complete ascending and descending current are marked by the arrows. A single current only is introduced, but they are very numerous in each cell, and present similar appearances to those of figs. 14 and 15. In the cell *a*, at the base, several currents are shewn, which perform the circuit of the cell, and pass around the nucleus. In the cells of the cuticle *d* the nucleus is shewn, and the small currents, which are too numerous and complex to be indicated by arrows. They are seen in the small cellules which surround the stoma *e*. They appear like a cobweb stretched across the cell; and it is only by patient observation that the motion of the minute particles can be perceived. Similar nuclei and currents are seen throughout the plant—very distinctly in the

petal, even when entire, and in all sections made of the stem and leaves. There is a perfect analogy between the circulation observed in these cells and that of the smaller particles in the cellules of the *hydrocharis*.

In fig. 18 is a magnified hair taken from the throat of the corolla of a species of *penstemon*. This hair *x y* is one continuous cell, which projects from the cuticle *a*. In this we observe currents in which minute particles are floating; and these take various directions, some continuing to the summit of the hair, whilst others turn and descend in several places: their direction is indicated by the arrows. Two currents here frequently unite in one channel. I have not observed a nucleus in these hairs. The existence of a circulation of fluid is, no doubt, very general throughout the cellular structure of plants; it has, I believe, been noticed in other instances than are above explained, but the observations require repetition. I must be allowed here to state, that I have derived great assistance in the observation of minute circulation from the very excellent triplet lenses made by Mr. Ross, upon the principle of Mr. Holland; an example of which will be seen in fig. 3, Plate V. of the present volume.

In figs. 19 and 20 are portions of tubes taken from the stipulæ of the *ficus elastica*, described by Mr. Schultz as vital vessels, in which he observes a fluid containing globules of a regular form to be circulating. A single current occupies the whole of these tubes, which inosculate in all directions; and, from his descriptions, we must figure to ourselves a circulation very similar to that seen in the web of a frog's foot. By tearing off a transparent layer from the stipulæ of the *ficus*, and placing it in water under the microscope, I have seen a rapid movement of the fluid and globules in one direction; but at present it

has to me always appeared more like the escape of a fluid from a tube, than the result of a continuous circulation. However, I cannot pretend, from the few observations I have been enabled to make, to set up an opinion in contradiction to the experience of M. Schultz. In fig. 19 is a portion of one of these vessels dissected from the surrounding tissue. It appears to terminate conically; but there will be seen at that extremity a small opening, which was, perhaps, in contact with a similar tube. In fig. 20 is a short fragment of one of the same series of vessels; but in this we observe distinct branchings at *a* and *b*. The direction of the current flowing from this tube is indicated by the arrows; and at *a* and *c* are masses of the globules, which, from some action of the air or water upon them, adhere in a mass as soon as they are exposed, and the liquid trickles out between them. Can these branchings be explained by the juxtaposition of elongated cells, and obliteration of the inter-cellular partitions, as seen in fig. 21, a specimen of cellular tissue from a part of the same stipule, where, as shewn at *a*, the intervening septa appear to have been obliterated? Or may there not have been two currents in these tubes, which are, perhaps, very elongated cells; and these two currents becoming of course united in one, and escaping together as soon as the cell has been ruptured? I mention these circumstances as objections which might, perhaps, be raised to the observations of M. Schultz, upon which he appears to have generalised too quickly. I have endeavoured to repeat his experiments on the leaf of the *chelidonium majus*, but have never succeeded in perceiving a circulation whilst it was attached to the branch; but on its being cut off, a rapid flow of the abundant juice was immediately perceptible. This may, of course, arise from

some error in the mode of conducting the examination. It appears, however, that the rotation of fluids in closed sacs or tubes has not as yet been more extensively observed. The circulation described by M. Schultz would certainly be a closer analogy to the motions of fluids in animals than we could, from other circumstances, suppose to exist.

No. XIV.

PLANING MACHINE.

An application was made, during the last session, on the part of the Society, to Mr. Joseph Clement, Prospect Place, Newington Butts, for liberty to publish in the Transactions, a full description of the Planing Machine recently set up by him in his manufactory. The requested permission was granted, without hesitation, by that very liberal and ingenious artist; and Mr. C. Varley was commissioned by the Society to make the drawings, and to prepare a description of the same, fully adequate to the complete illustration of this beautiful machine. The scale of the principal figures in Plate VIII. is three-tenths of an inch to a foot, and of those in Plates IX. and X. one inch to a foot.

The engineers' planing machine is used to cut metal, so as to produce clean and perfectly straight or flat surfaces. It differs greatly from the carpenter's tool called a plane, the length and straightness of which prevent the cutter from descending into any hollows; it therefore gradually removes the prominences, and the cutter is never allowed to project through deeper than the thickness of the shaving which the workman can safely take off without tearing up the grain of the wood. The wider such a plane is the flatter will it work; but, as the